APPLICATION
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Title: **System and Method for Protecting Equipment from Damage Due to Low or Rapidly Changing Temperatures**

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Application Of: Roy P. Johnson and Alan J. Orndorff

For: System and Method for Protecting Equipment from Damage Due to Low or Rapidly Changing Temperatures

BACKGROUND OF THE INVENTION

[0001] The present invention relates to back-up heating systems, and methods of operation thereof, for supplying the heat necessary to avoid damage to expensive equipment which may be caused by low temperatures and/or rapid temperature changes. More specifically, the invention relates to systems and methods of augmenting the supply of heat to enclosed areas, particularly those containing expensive, heat-sensitive production equipment, such as that used in the production of semiconductor components and circuits, in the event of failure of the primary power supply during periods of low outdoor temperatures.

[0002] In many production facilities, several buildings are located about a campus which includes a central utility plant (hereinafter denoted CUP) having gas/oil fired boilers and large, electrically powered pumps for providing, when outside temperatures require, space heating to the fabrication buildings and possibly to office and other buildings as well. In the event of a power outage, i.e., a cessation of electrical power received by the equipment at the CUP which relies upon such power for supplying heat, back-up means must be provided for supplying at least some of the necessary space heating. Such back-up means commonly takes the form of a gasoline or diesel fueled engine which drives a generator at the CUP to provide the electricity used to power pumps and other emergency equipment to circulate heated water to the areas requiring heat.

[0003] Building codes commonly require that buildings containing semiconductor fabrication equipment have an air exhaust system, with the consequent necessity of taking in outside air in a quantity sufficient to replace the exhaust air. The exhaust fans and intake air handing systems are also electrically powered, with a separate motor/generator provided in each building to supply the required power during periods of primary electrical supply outages. Upon the occurrence of a power outage, both the exhaust and make-up air handling systems are, in typical systems, ramped down to 50% of their flow under normal conditions, thereby satisfying code requirements. However, regardless of the degree of thermal integrity (insulation) of the building, significant amounts of outside air, which may be very cold, must still enter the building on a continuous basis. Although the motor/generator at the CUP will supply electricity sufficient to provide enough heat to the incoming air as to prevent the temperature in fabrication areas from reaching the freezing mark, the temperature may fall to a point, or the rate of temperature change may be so rapid, as to cause permanent damage to elements of the production equipment, such as lenses of photolithography equipment used in semiconductor fabrication. When this occurs, not only is there the expense of purchasing and installing new components to replace those damaged, but the much greater expense of lost production time while the equipment is out of service.

[0004] The conventional approach to the problem outlined above has taken one of two forms: 1. expand the emergency power generation system in the CUP by providing larger and/or additional engine/generators or 2. provide a local boiler, connected to the building emergency power generation system, in each building requiring supplemental heat. Both approaches involve high initial expense and

ongoing maintenance, in addition to requiring significant space, possibly involving expansion of existing buildings.

[0005] The principal object of the present invention is to provide a simple, relatively inexpensive, yet durable and reliable system and method for protecting expensive fabrication equipment from damage due to low temperature and/or to rapid temperature change.

[0006] Another object is to provide a novel and improved system and method, operable in the event of interruption in the primary electrical power supply under conditions of low outside temperatures, for adding heat to air entering an enclosed space in excess of the heat provided by a conventional, back-up heating system including an engine and generator.

[0007] A further object is to provide a unique and efficient system and method of utilizing heat energy generated by an internal combustion engine driving an electrical generator in providing, under conditions of low outside temperatures, heat to enclosed spaces containing production equipment which is subject to damage by low temperatures and/or by rapid temperature changes.

[0008] Other objects will in part be obvious and will in part appear hereinafter.

SUMMARY OF THE INVENTION

[0009] The present invention is emloyed in a production facility comprising a plurality of buildings, at least some of which house semiconductor fabrication tooling, and a CUP containing, among other equipment, fluid-fired boilers, each with an associated, electrically powered pump, the combined boiler and pump being referred to collectively as a "boiler system." The boiler systems supply hot water

used, when outside air is below a predetermined temperature, to provide heat to areas in the fabrication buildings containing production equipment. The primary electrical power source for pump operation is the usual, commercial supply from the local public utility, or the like. In the event of a power outage, i.e., interruption of power from the primary supply, at least one of the boiler systems operates on electrical power from a back-up source comprising a generator driven by a diesel or gasoline fueled, internal combustion engine. A separate motor/generator system is located in each of the fabrication buildings to operate the air handling system during periods of primary power outage, and includes the usual, heat-rejecting radiator, normally located outside the building, through which engine coolant is circulated.

[0010] In the system of the present invention, a heat exchanger, having two, mutually exclusive, liquid flow paths, is provided in each fabrication building, in addition to the conventional equipment mentioned earlier. During periods of primary power outage when outside temperature is below the value requiring heating of the fabrication buildings, liquid coolant from the motor/generator in the fabrication building is diverted, through operation of a three-way valve, from the radiator to one of the flow paths through the heat exchanger. The heating water supply from the CUP passes through the conventional heating system (space heater) in the fabrication building, and is then diverted, through operation of a second three-way valve and booster pump, through the other flow path of the heat exchanger to receive heat from the engine coolant therein, then passing again through the heating system, thereby providing additional heat to the area containing the production tooling. Preferably, the space heaters are located in the intake of the make-up air which is introduced from the outside to compensate for air which is exhausted from the production equipment.

This augmentation of the temperature in the fabrication areas serves to prevent damage which could otherwise be incurred by equipment which is sensitive to rapid temperature changes.

[0011] The foregoing and other features of construction and operation of the invention will be more readily understood and fully appreciated from the following detailed disclosure, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Figure 1 is a diagrammatic illustration of a manufacturing facility comprising multiple buildings and illustrating the flow of water for heating purposes to the various buildings, as well as the flow of electricity from both primary and secondary supplies to electrically powered equipment;

[0013] Figure 2 is a diagrammatic, front elevation of one of the buildings of Figure 1; and

[0014] Figure 3 is a diagrammatic showing of a portion of Figure 1 directed particularly to elements most closely related to the present invention.

[0015] For greater clarity throughout the Figures, lines carrying heating water to and from the various buildings and elements therein are shown in solid lines, and electrical lines are shown as long and short dashed lines.

DETAILED DESCRIPTION

[0016] In Figure 1, block 10 represents a central utility plant (CUP), i.e., a building containing, among other things, the apparatus for supplying heat, in the form of hot water, to office building 12 and semiconductor fabrication buildings 14 and 16. A plurality of boiler systems 18 each include a fluid fired boiler and large, circulation pump receiving electrical power from a remote, commercial supply 20 over line 22.

Water is heated in boiler systems 18 to a predetermined temperature and is circulated by the pumps through hot water supply line 24 and is supplied to conventional hot water radiation heaters 32, 34 and 36 within buildings 12, 14 and 16, respectively, through lines 26, 28, and 30. After transferring heat to the air within the buildings, the water is returned through lines 38, 40 and 42 from buildings 12, 14 and 16, respectively, to return line 44 and thence to boiler systems 18 for re-heating.

[0017] Figure 2 diagrammatically illustrates, in front elevation, a semiconductor fabrication building having structural features to which buildings 14 and 16 conform. The building is divided by solid barrier 46 into upper and lower compartments 48 and 50, respectively. Fabrication of semiconductor components, chips, circuits, and the like, is performed, at least partially, by production tools, denoted generally by reference numerals 52 and 54, in lower compartment 50. Tools 52 and 54 are of a conventional form which includes components, e.g., lenses used in photolithography equipment, which are subject to damage or destruction when subjected to low and/or rapidly changing temperatures. Such equipment requires an exhaust system and a constant supply of fresh, clean air to replace that which is exhausted. In the illustrated system, air is exhausted from tools 52 and 54 through ducts 56 and 58, respectively, and is moved by exhaust fans or blowers within enclosure 60, which may also contain any necessary air treatment equipment, in upper compartment 48 to outside atmosphere. The exhaust fans are driven by an electric motor, indicated by the block numbered 62, powered by electricity from source 20 through line 64.

[0018] An amount of air substantially equal to that exhausted from the building must be taken in from outside atmosphere. This is accomplished by

providing air intake openings through which atmospheric air, indicated by arrows 66, is passed to air treatment enclosure 68 in upper compartment 48. Intake fans within enclosure 68 are powered by an electric motor 70 powered by electricity from source 20 on line 71. When heating is required, the air passing through enclosure 68 is heated by the previously mentioned hot water heater, the heater shown in Figure 2 being numbered 34, 36 to indicate that it is the same as the heaters so numbered in Figure 1 for buildings 14 and 16, respectively. Also, the lines through which heating water is carried to and from heaters 34, 36 are numbered 40, 42, respectively, corresponding to their numbering in Figure 1. Essentially all particulate matter down to sub-micron size is removed by filters in enclosure 68 and the air is heated by the hot water heater before being delivered to plenum 72 in the upper part of lower compartment 50, as indicated by arrows 74. Air from plenum 72 passes vertically downward, in laminar fashion, into lower compartment 50, as shown by the arrows numbered 76, and maintains both the pressure and temperature therein within a desired range.

[0019] In the event of failure or interruption of electrical power from source 20 for any reason during periods when heat is required for the various buildings, it is common practice to immediately commence operation of auxiliary generators, driven by an internal combustion engine to provide the electricity needed to continue operation of one of boiler systems 18. Engine/generator 78 are shown in Figure 1 within CUP 10, supplying electricity on line 80 to the circulating pump for the heated water in one of boiler systems 18, which becomes the single, operative boiler system, providing heating water through line 24 and receiving return water through line 44. Although fabrication operations are normally suspended during periods of primary

power outages, it is still a requirement (e.g., by building codes) that air intake and exhaust continue to operate in fabrication buildings. The volume of air per unit of time, usually expressed in terms of cubic feet or cubic meters per minute, may be, and normally is, reduced to 50% of the volume handled during normal operation, but in a typical fabrication building this may still represent 500,000 cfm. Electricity for operating the air intake and exhaust systems, and often to maintain production tooling in a stand-by condition, is conventionally provided by an engine/generator set in each fabrication building.

[0020] The reference numerals used in Figure 2 to denote the exhaust and intake fans and the lines through which they receive electricity from source 20, i.e., numerals 62, 70, 64 and 71, are used in Figure 1 to denote the same elements in building 14, while the corresponding elements in building 16 are noted by the same reference numerals with a prime sign (') added. Engine/generators 82, 82' are provided in buildings 14 and 16, respectively, to provide the electricity necessary to operate motors 62, 62' and 70, 70' in the event of power failure at source 20. Electricity to motors 62, 62' is provided on lines 84, 84', respectively, and that for motors 70, 70' is provided on lines 86, 86', respectively. Liquid coolant used in engine/generators 82, 82' is normally circulated to conventional radiators and the heat rejected to outside air before return to the respective engine/generator. The outdoor radiators for engine/generators 82, 82' are shown in Figure 1, denoted by reference numerals 88, 88', respectively.

[0021] All of the foregoing conforms to conventional practice. The use of a single boiler at the CUP will, under virtually all reasonably anticipated circumstances, provide sufficient heat to the various buildings to maintain inside temperatures above

the freezing point, even with the intake and exhaust systems in the fabrication buildings operating at 50% of normal capacity. However, this amount of heat alone may not be sufficient to prevent damage to temperature-sensitive elements of the production tooling. Traditional means of addressing this problem have included placing more or larger engine/generators at the CUP, and providing a boiler and associated pumps, driven by an additional engine generator, in each fabrication building. Both approaches are very expensive and require additional space, sometimes involving expanding the CUP and/or fabrication buildings.

[0022] The essence of the present invention may be seen with reference to Figure 3, and portions of Figure 1. Engine/generator 82 includes a conventional liquid cooling system. Coolant leaves the engine through line 90 and, when outside temperatures are above a predetermined value, passes through 3-way valve 92 to outside radiator 88 where heat is rejected to outside air, and returns to the engine through lines 94 and 96. When the outside temperature is below the predetermined value, valve 92 is switched to direct coolant from line 90 through line 98 to heat exchanger 100. After passing through heat exchanger 100 the coolant is returned to the engine via lines 102 and 96. Heat exchanger 100 is also connected to supply and return heating water lines 28 and 40, respectively, through lines 104 and 106. Also, an additional 3-way valve 108 and booster pump 110 are provided in line 106.

[0023] When outside temperature is high enough that auxiliary heat is not required during a power outage, engine/generator 82 (and 82') operates to provide electricity for operating the intake and exhaust air systems, and possibly to maintain production equipment in a stand-by mode, with engine coolant directed to and from the outdoor radiator(s). When outside air temperature is below the point where heat

must be provided, engine/generator 78 is operated to power the pump circulating heated water from its associated boiler system 18, and both of valves 92 and 108, together with booster pump 110 are actuated. This causes heating water which has passed through heater 34 and rejected some heat to the air coming into building 14 to circulate to heat exchanger 100 where it is reheated to some extent by engine coolant passing through a separate path within the heat exchanger. The re-heated water then passes again through heater 34, thereby rejecting additional heat to intake air in building 14.

[0024] The foregoing explanation with reference to elements associated with building 14 apply, of course, to the corresponding elements in building 16, and any additional fabrication buildings which may be included in the production facility. The heat which is recaptured from the engine coolant is sufficient to prevent a rapid temperature drop which may damage or destroy components of production tooling such as lenses of photolithography equipment. The system is reliable and efficient, as well as significantly less expensive to provide, install, service and house than conventional systems for carrying out the same function.